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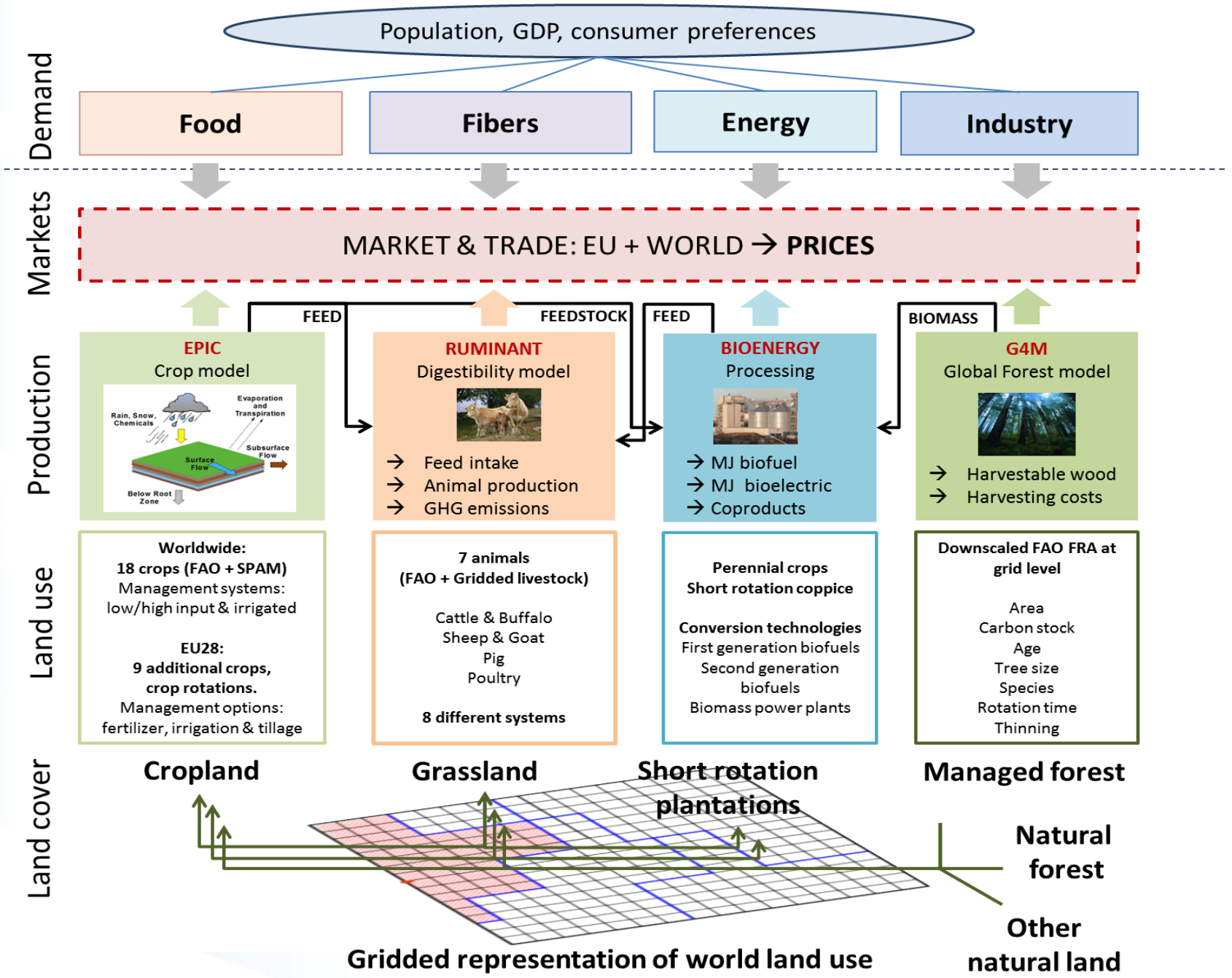
science for global insight

Reducing greenhouse gas emissions in agriculture without compromising food security?

Stefan Frank, Petr Havlík, JF. Soussana, A. Levesque, H. Valin, E. Wollenberg, U. Kleinwechter, O. Fricko, M. Gusti, M. Herrero, P. Smith, T. Hasegawa, F. Kraxner, and M. Obersteiner

Introduction

- AFOLU sector is a significant source for GHG emissions
  - accounts for around 24% of global emissions
- The sector will need to contribute like other sector significantly to GHG reductions
  - Become net negative towards 2100 to achieve 2 C target
- Potential trade-off between climate change mitigation and food security
  - Land competition for biomass vs. food production
  - Expansion of agricultural areas vs. protection of forests,
  - Implications on food prices and food consumption


Population, GDP, consumer preferences
Demand
Food
Fibers
Energy
Industry
Markets
MARKET & TRADE: EU + WORLD → PRICES
Production
FEED
FEEDSTOCK
FEED
BIOMASS
EPIC
Crop model
Rain, Snow, Chemicals
Evaporation and Transpiration
Subsurface Flow
Surface Flow
Below Root Zone
RUMINANT
Digestibility model
→ Feed intake
→ Animal production
→ GHG emissions
BIOENERGY
Processing
→ MJ biofuel
→ MJ bioelectric
→ Coproducts
G4M
Global Forest model
→ Harvestable wood
→ Harvesting costs
Land use
Worldwide:
18 crops (FAO + SPAM)
Management systems:
low/high input & irrigated
EU28:
9 additional crops,
crop rotations.
Management options:
fertilizer, irrigation & tillage
7 animals
(FAO + Gridded livestock)
Cattle & Buffalo
Sheep & Goat
Pig
Poultry
8 different systems
Perennial crops
Short rotation coppice
Conversion technologies
First generation biofuels
Second generation biofuels
Biomass power plants
Downscaled FAO FRA at grid level
Area
Carbon stock
Age
Tree size
Species
Rotation time
Thinning
Land cover
Cropland
Grassland
Short rotation plantations
Managed forest
Natural forest
Other natural land
Gridded representation of world land use

GHG mitigation in GLOBIOM

- **Soil carbon sequestration options** (Smith et al., 2008)
  - Crop & grassland options
- **Technical livestock non-CO2 add-on options** (EPA, 2008)
- **Structural adjustments** (Havlík et al., 2014)
  - Reallocation of production within a region
  - Transition of livestock and crop production systems
  - International trade
- **Demand side** (Valin et al., 2015)
  - Consumers' response to food prices
  - Diet shifts (not considered in the presented results)

Key scenario drivers

SSP2 (Fricko et al., 2016): Population, GDP, technological change, diets…

Scenario name	Radiative forcing levels in 2100	Carbon price in 2050	Bioenergy in 2050
3.1 °C scenario	6.0 W/m^2	2 \$/tCO_2eq	53 EJ
2.6 °C scenario	4.5 W/m^2	10 \$/tCO_2eq	61 EJ
2.2 °C scenario	3.4 W/m^2	25 \$/tCO_2eq	70 EJ
2.0 °C scenario	2.6 W/m^2	65 \$/tCO_2eq	81 EJ
1.5 °C scenario	1.9 W/m^2	190 \$/tCO_2eq	103 EJ

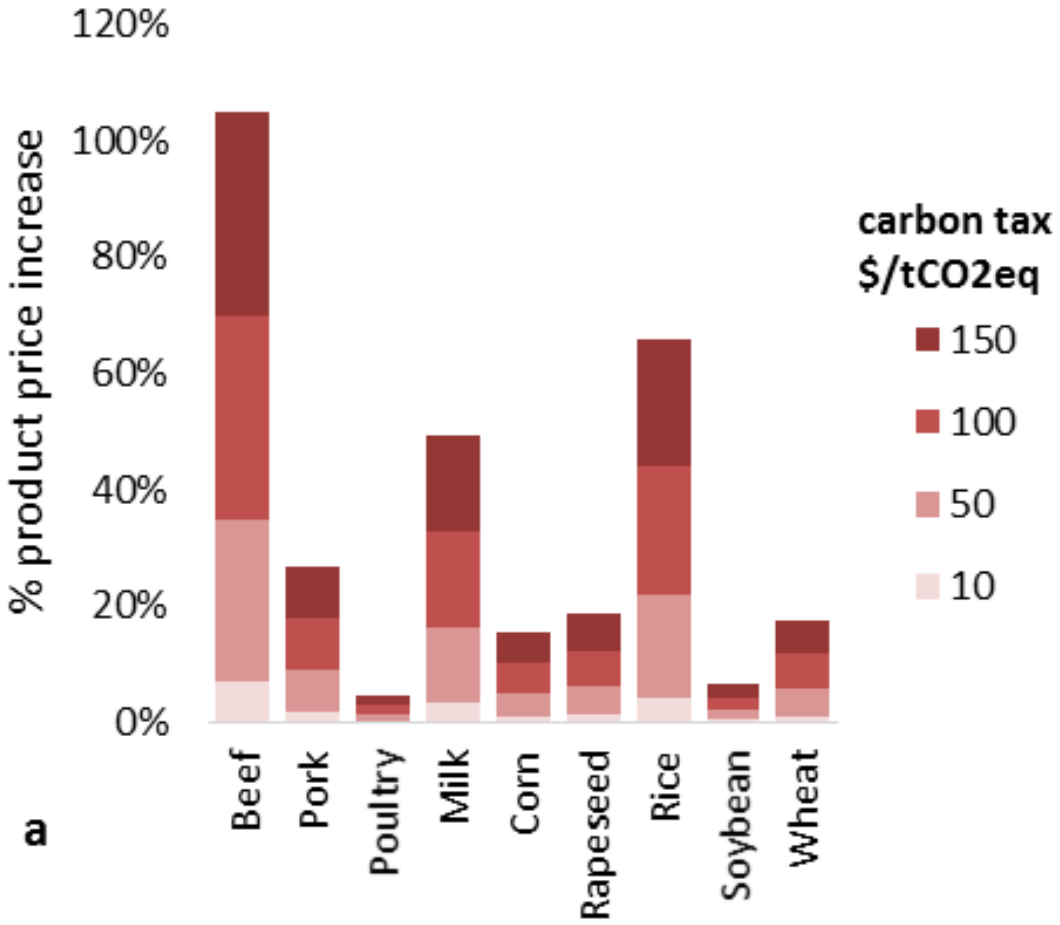
Scenario design

SSP2 set-up + mitigation efforts

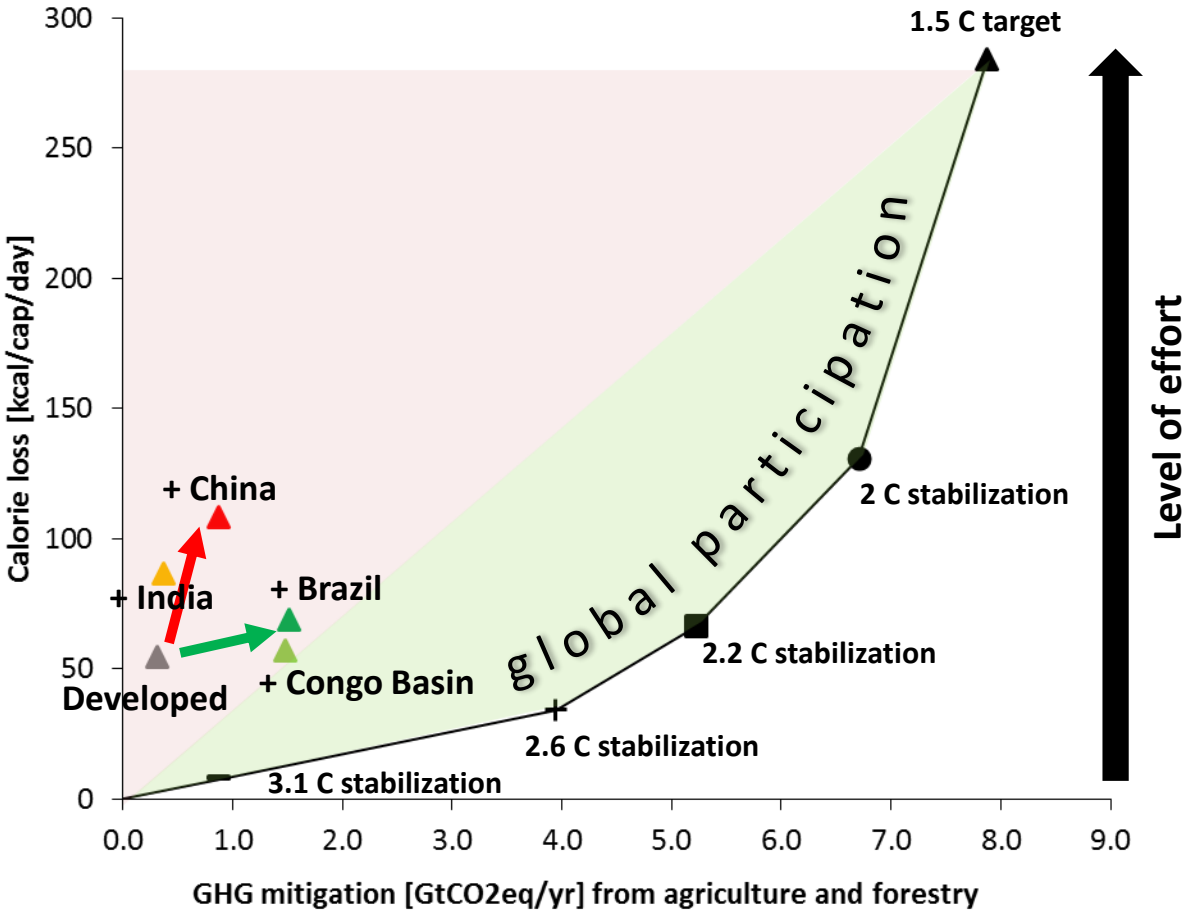
- Full global participation
  - Radiative forcing levels 6.0 – 1.9 W/m2 based on MESSAGE-GLOBIOM

- Regional participation only
  - Carbon price for AFOLU in developed countries only
  - Carbon price for AFOLU in developed countries and Brazil
  - Carbon price for AFOLU in developed countries and India
  - ….

Carbon tax impact on food prices

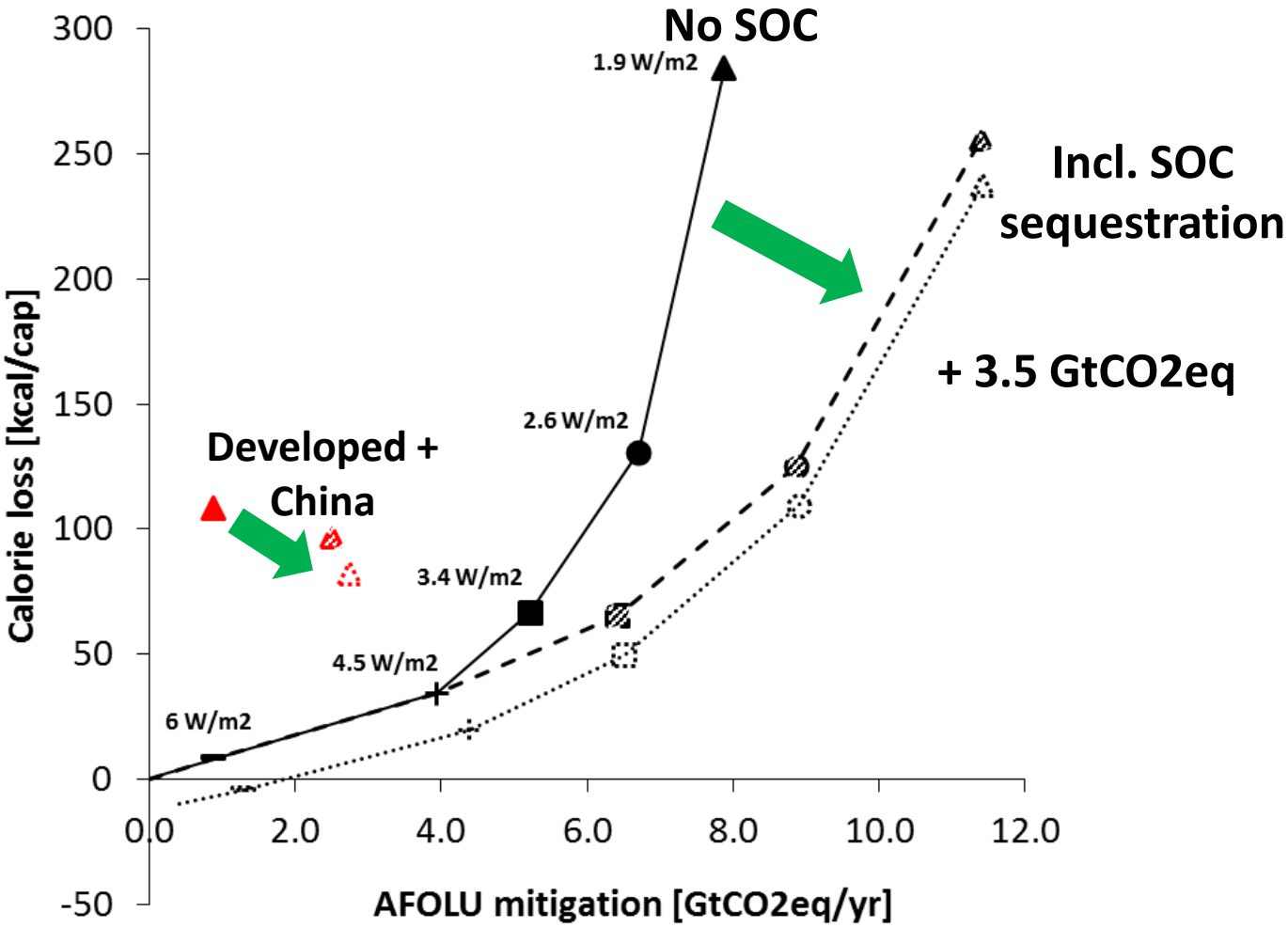


Regional land use mitigation hot-spots

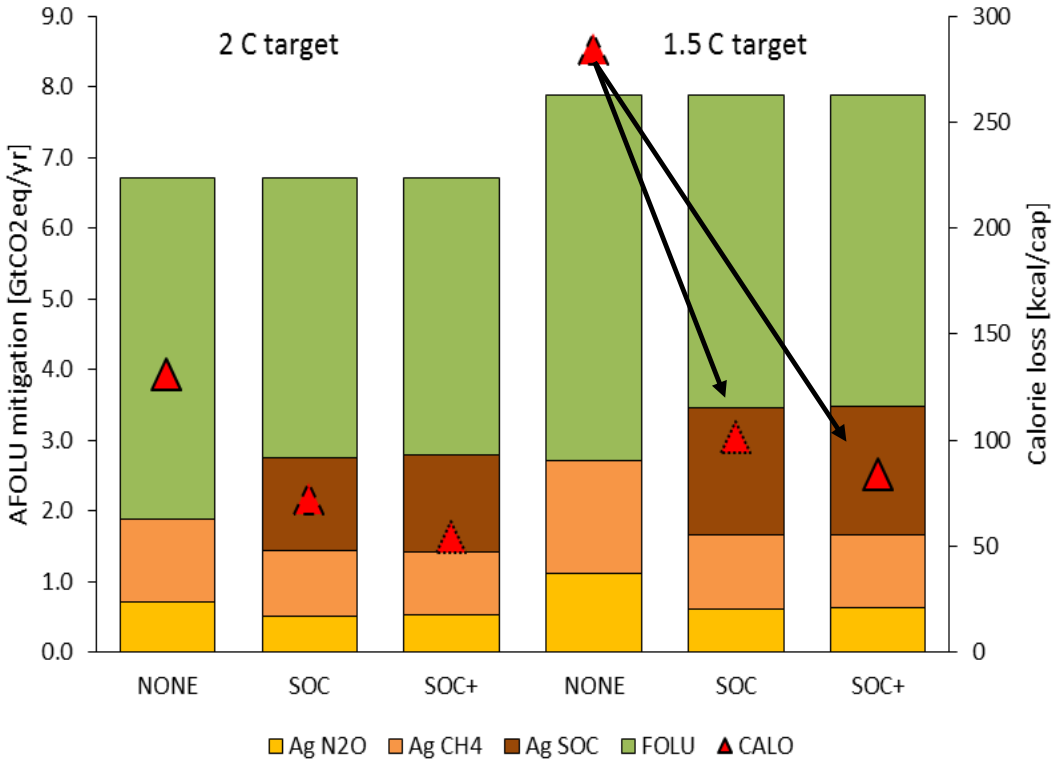


- Land rich countries with LUC emissions offer significant mitigation potential with limited food security trade-offs
- Highly populated countries with intensive agriculture show limited potential with large trade-offs

SOC sequestration and food security



SOC sequestration and food security



- SOC sequestration significant co-benefits food security
- -65% impact on calorie consumption
- -75% on undernourishment

Conclusions

- Globally coordinated efforts even with lower ambition outperform regional or sectorial approaches
- In the absence of global agreements, second best policies need to be implemented
- Significant potential for GHG abatement in the AFOLU sector with limited trade-offs:
  - Mitigation of land use change emissions: regional mitigation hot-spots i.e. Indonesia or Congo Basin countries should be targeted
  - SOC sequestration through improved crop- and grassland management, and restoration of organic and degraded soils
- SOC sequestration offers co-benefits for food security
- Full mitigation portfolio needed to manage trade-offs with other objectives aside climate change mitigation

Thank you !